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The Egg and Breeding Habits of Oncomelania quadrasi Mlldff., the Schistosomiasis Snail of the Philippines [1]

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Since 1895 when *Oncomelania quadrasi* from the Philippines was first described by Moellendorff, the egg and egg-laying habits of this species have remained entirely unknown. The recent discovery of the egg on Leyte, P. I., has aided further studies in the natural history, control and taxonomic relationships of this snail. The four-month search was made difficult by the presence of other egg-laying mollusks and the then unknown fact that the egg is camouflaged by means of a jacket of sand.

The natural habitat of *Oncomelania quadrasi* Mlldff. is always limited to small, slowly-flowing, fresh-water creeks or boggy areas which are being constantly supplied with a fresh flow of water. The snail is amphibious, but never absent from shady and moist, if not actually flooded, creek beds. It is in these localities that the females find conditions suitable for laying eggs. Rotting, water-logged coconut husks, sticks, boards and dead leaves are the only surfaces on which eggs have been found.

Eggs are laid singly, and rarely have two been seen side by side. It is not known at what frequency or how many eggs are

[1] The opinions expressed in this article are those of the author and are not to be construed as official or reflecting the views of the Navy Department, or of the Naval Service at large.

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laid by one female. On a husk bearing 25 eggs it was noticed that 5 females were present. The greatest concentration of eggs observed was on a section of coconut husk four square inches where twelve eggs had been laid.

Adult males and females copulate most frequently during rainy spells, especially at night or when the sky is heavily overcast by clouds. The two sexes do not appear to attract each other from a distance, but once in contact, the female remains quiescent while the male slides over the back of her shell. The male plunges its large, extended penis or verge into the mantle cavity of the female in the region just behind the head. Copulating pairs have been seen to remain in this interlocked position for more than two hours. Mating of pairs under water has never been observed.

Soon after copulation, the female seeks a moist area on the surface of a coconut husk, usually within an inch of the water line and there deposits a single, clear, round egg about 0.7 mm. in diameter. Following this, comes a slow and careful process of patting down small grains of sand over the egg to form an agglutinated capsule or jacket. In most cases, the female utilizes its own soft fecal pellets which consist almost entirely of sand. During this process there is an abnormally large amount of mucus secreted, probably from the accessory gland, which aids in cementing the grains of sand into a firm jacket. The proboscis and foot of the female are used to knead and shape the capsule. Though expertly camouflaged to match nearby lumps of mud or sand, the tiny capsule, 1 to 1.5 mm. in diameter (Plate 9, figs. 1, 2), can be detected readily with the aid of a hand lens, because it has an artificial-looking, dome-like outline.

Usually the day following its deposit, the egg commences its first cleavage. Second cleavage occurs about four hours after the first. During the first week, the embryo, set off to one side in the clear, colorless egg mass, remains yellow in color and about 0.1 to 0.2 mm. in diameter. In late cleavage, development occurs only in the upper half of the embryo, while the lower half remains dormant. By the ninth day, the first part of the apex of the shell appears (fig. 3), followed on the eleventh by the appearance of the two black eyes and the thin, translucent operculum. The shell continues to increase in size

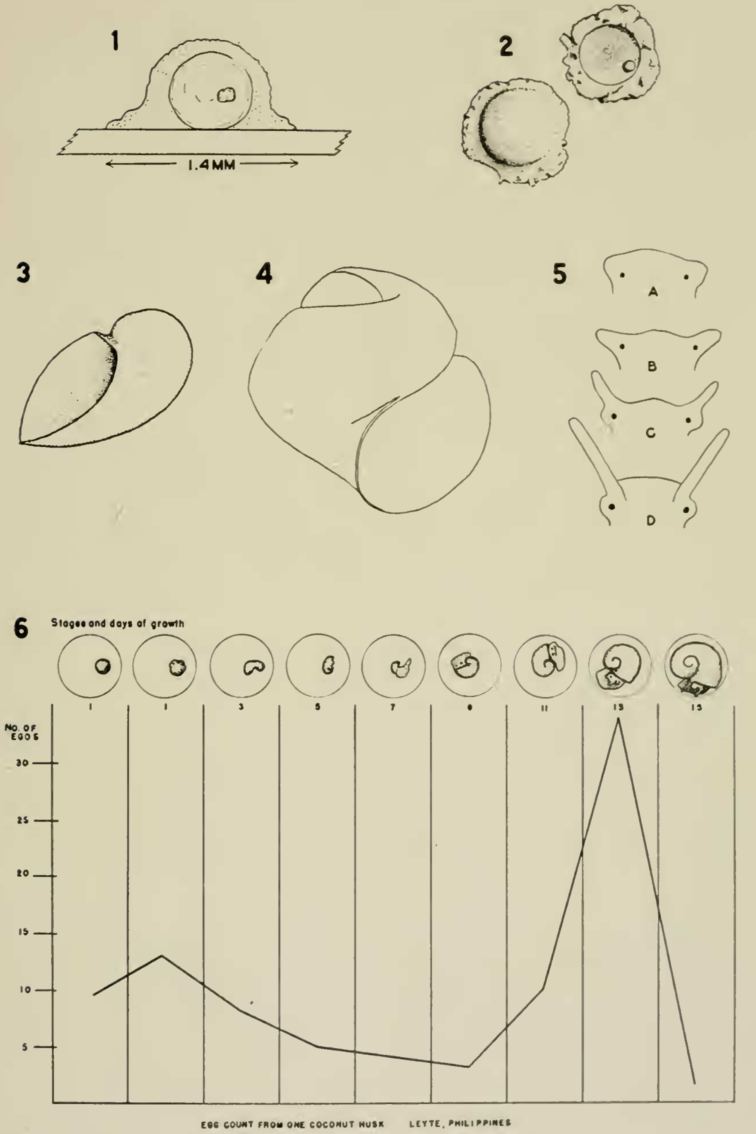

Plate 9. Fig. 1. A cross-section of egg in sand jacket. Fig. 2. Top and bottom view of jacket. Fig. 3. Nuclear shell whorl 8 days old (animal removed) x50. Fig. 4. Newly hatched shell (animal removed) x50. Fig. 5. Development of eyes and tentacles: A, 9 days; B, 11 days; C, 13 days; D, 15 days.

by the addition of whorls. When the embryonic snail is ready to hatch, on the fifteenth day, it has produced $1\frac{1}{2}$ to $1\frac{3}{4}$ whorls (fig. 4). The development of the snail is graphically represented in Plate 9, fig. 6.

During early and middle stages of development the embryo revolves slowly, end over end, in one direction, as is the case with most gastropod veligers. This action is not continuous, but more frequent in the final stages and is accomplished by the action of exceedingly minute cilia on the underside of the foot.

A few days before hatching, the embryonic snail is restless and often moves its head and foot in and out of the shell. The jaws and radula (ribbon of teeth within the proboscis) begin to function. The sand capsule is usually eaten away when the young is ready to emerge. Crawling and feeding begin at once after hatching, and within 12 hours after birth the young snail will have produced enough fecal material to equal its own bulk.

Motion and a yellowish color are characteristic of life throughout embryonic development. Dead embryos may be detected by the absence of motion and the presence of a milky-white color.

Several eggs *in situ* on pieces of coconut husk were dried in the laboratory at room temperature (84° F.) to determine the effect of desiccation. All of the eggs were alive after a period of 12 hours. However, under the same conditions, 10 (83%) eggs were dead after 48 hours of drying. Desiccation for 12 hours under artificial light at a temperature of 108° F. killed 10 (100%) eggs. Direct sunlight would probably kill eggs in an even shorter time.

Figure 6 graphically represents the results of an inspection of a coconut husk taken from Gacao Creek, 1 mile southwest of Palo, Leyte. The husk was found in two inches of water hidden in the tall, shady grass of the creek bed. All egg capsules were removed, opened, and recorded according to the amount of embryological development. Of the 100 eggs removed, 14 were found to contain dead embryos. The graph shows two peaks, one occurring at an early cleavage stage, the other at a much later stage of development, two or three days from hatching. Four days previous to taking the husk from the creek, rains had fallen for 24 hours and the level of the water in the creek had risen a foot. This would seem to indicate that soon after the occurrence of a heavy rain and rise in the level of water, females began to lay eggs more actively. The second peak represents a much earlier spurt of egg-laying, approximately 14 days previously. About 20 empty capsules with their tops punctured were found on the husk. In addition to this, it was noted that there was an increase in the number of newly hatched snails in the surrounding colony of snails. This phenomenon has been observed several times following a rise in the level of water in the creek and it is likely that the current of water aids in the release of young snails from the capsules. This may also account for the drop in the number of snails in the last stages of development (15 days) shown in the graph.

Egg counts on sticks, old boards and other coconut husks in the same creek showed similar peaks but not at the same stage of development. This is to be expected, since egg-laying is governed by the amount of water in the immediate area of the husk, and not directly by the rainfall. In Gacao Creek, the degree of moisture or amount of water varies a great deal even in spots less than twenty feet apart.

It is quite possible that fully developed embryos ready to hatch do not break out of their capsules until the arrival of favorable flood periods which occur two or three times a month during the summer. Measurements of snails of all ages in a colony show peaks in the size of individuals in the population and these peaks indicate that the times of hatching are unevenly spaced. Such peaks most likely represent previous rainy spells that aided hatching.

Seasonal increase in egg-laying on the island of Leyte is as yet undetermined, but it is likely that during late October, November and December, when there is an abundance of rain and overcast skies, there is an increase in mating and egg-laying.

This type of small, single, sand-jacketed egg is common to the members of the genus *Oncomelania*. The egg of *O. nosophora* Robson (syn.: *Katayama nosophora yoshidae* Bartsch, *K. lii* Bartsch, *K. fausti* Bartsch, *K. cantoni* Bartsch) was first discovered by S. Sugiura (1933) in Japan. Of them Sugiura says, "The eggs of this snail are usually laid singly and they are entirely covered with a layer of mud particles, which is incidentally attached to the outer mucous shell-membranes, so that they look like small grains of mud or sand." His remarks and clear illustrations parallel our findings in *O. quadrasi* Mlldff. of the Philippines.

Fu-ching Li (1934) published a figure of what he then believed to be the eggs of the ribbed *Oncomelania hupensis* Gredler of China. Those were probably the eggs of some Planorbid snail, for the next year (Li, 1935) he corrected this error and described and figured eggs of *O. hupensis* which are identical to those of *O. quadrasi* and *O. nosophora*. Bartsch in 1936 overlooked this correction and published the incorrect drawings of *O. hupensis* eggs. Li's manuscript drawings of the eggs of *Katayama lii* Bartsch (= *O. nosophora*) included in the same paper (Bartsch, 1936) are the same as the eggs of the Japanese and Philippine species.

Under adverse or aquarium conditions *Oncomelania* will sometimes lay eggs without adding a sand jacket.

A study of the anatomy, shell characters, ecologic variations and radulae of living specimens of Chinese, Japanese and Philippine *Oncomelania* has led the author to the belief that the genera *Schistosomophora* Bartsch and *Katayama* Robson are synonymous with Gredler's genus, *Oncomelania*. All known species of *Oncomelania*, including *O. formosana* Pils. and Hirase, possess a characteristic yellow "eyebrow" or streak of yellow color granules embedded in the skin just above the eye. Nine months' search in the field in the Pacific and China has failed to bring to light any other freshwater snail with this character.

New Localities For Oncomelania quadrasi Mlldff.

During the author's four-month survey for snails in the Philippines, a number of new localities harboring *Oncomelania quadrasi* Mlldff. were discovered which seem worthy of recording at this time. In the following list of new Philippine localities, the percentage of snails infected with the cercariae of *Schistosoma japonicum* Katsurada followed by the number of snails examined are included in parentheses. In cases where no figures are given, the snails were not examined for cercariae.

Leyte Island

1. San Isidro, 4 miles E.N.E. of Dagami, 2 miles north of the Binahaan River. June 17, 1945, (10%–10).
2. One mile west of Alangalang, near road. June 10, 1945.
3. Two miles north of Burauan, north side of road. July 4, 1945, (0%–300).
4. Northern and southern outskirts of Santa Fe. July 24, 1945.

Samar Island

5. Sitio Nadang, 2.1 miles N.E. of Oquendo on Route No. 1. July 16, 1945, (1%–363).
6. Western outskirts of Gandara. July 10, 1945.
7. A half mile north of San Miguel, 2 miles south of Gandara on Route No. 1. July 10, 1945.
8. East side of Cabulaloan Valley, 3 miles west of Bayog, Catubic River area. July 17, 1945.
9. Barrio of Malijao, 10 miles south of Catarman. July 19, 1945, (0%–187).
10. Sitio Daganas, 2 miles west of Catarman. July 18, 1945, (4%–134).

Mindanao Island

11. Kilometer post No. 42, between Tubod and Alegria, Lake Mainit drainage. August 31, 1945.

12. One mile N.E. of Mainit, near road, Lake Mainit drainage. August 31, 1945.

13. Ditch running into Lake Lanao, 2 miles S.E. of Dansalan City. September 11, 1945.

Though the snail has not been found on any island of the Philippines other than the four previously known to harbor it (Leyte, Mindanao, Mindoro and Samar), the new localities recently discovered indicate that there may be a much more general distribution of this snail than was formerly supposed. Therefore, it is not unlikely that it will be found on other islands of the Philippines in future surveys.

It is important to note that although no human cases of schistosomiasis have been reported from Lake Lanao, Mindanao, the recent discovery of the intermediate snail host in this area serves as a warning of possible future outbreaks of the disease.

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